Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 64 (2013) 1302 – 1309

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference On DESIGN AND MANUFACTURING, IConDM 2013

Comment [S1]: Elsevier to update volume and page numbers.

A Real Time Foot Pressure Measurement For Early Detection Of Ulcer Formation In Diabetics Patients Using Labview

A.N.Nithyaa[a], R.Premkumar[b], S.Dhivya[c], M.Vennila[d]

[a]*Department of Biomedical Engineering, Rajalakshmi Engineering College,Chennai-602105, India*
[b]*Department of Biomedical Engineering, Rajalakshmi Engineering College,Chennai-602105, India*
[c]*Department of Electronics and Communication Engineering, SSN College of Engineering,Chennai-603110, India*
[d]*Medical Electronics, Rajalakshmi Engineering College,Chennai-602105, India*

Abstract

Diabetic foot ulcer is one of the major complications caused due to Diabetes Mellitus. Elevation of blood sugar level above normal conditions causes several vascular problems (constriction of blood vessels) which lead to improper circulation of blood to the feet. This leads to gangrene formation and loss of sensation in the patient's foot. Majority of the diabetics ignore this problem, which ultimately leads to lower leg amputation. Our project aims to identify the patients who are likely to develop diabetic foot ulcers at an early stage. We accomplish this by fixing pressure sensors in six pressure points of the foot. The foot pressure readings are converted into corresponding voltage output by the sensor. These voltage readings are amplified using an amplification unit. The voltage data are read using a data acquisition device which is connected to a personal computer. We use LabVIEW for analyzing the voltage readings in a graphical format. The peak voltage reading indicates that the patient might be prone to develop a foot ulcer in that particular area of the foot.

Keyword: Diabetic Foot Ulcer; Diabetes Mellitus; Pressure Sensor; Data Acquisition Device; LabVIEW Software.

E-mail address: nithyaa.an@rajalakshmi.edu.in (A.N.Nithyaa).

1. Introduction

The aim of our project is to design a pressure mat, used to detect the foot pressure value of diabetic patients and alerting them for their corresponding output values. Diabetes mellitus is a group of metabolic diseases characterized by high blood sugar (glucose) levels that result from defects in insulin secretion, or action, or both.

doi:10.1016/j.proeng.2013.09.211

Diabetes mellitus, commonly referred to as diabetes was first identified as a disease associated with "sweet urine," and excessive muscle loss in the ancient world. Elevated levels of blood glucose (hyperglycemia) lead to spillage of glucose into the urine, hence the term sweet urine. Normally, blood glucose levels are tightly controlled by insulin, a hormone produced by the pancreas. Insulin lowers the blood glucose level. 3-D Foot Print Device has been used to measure the plantar foot pressures for normal subjects and diabetic patients with neurotropic ulcers [1]. The results confirm that patients with peripheral neuropathy develop over 40%higher forefoot pressures when compared with normal subjects [1]. A 3-D Foot Print Device is used to analyze the gait of diabetic and normal subjects.

1.1. Diabetic Foot Ulcer

Diabetes mellitus is a group of metabolic diseases characterized by high blood sugar (glucose) levels that result from defects in insulin secretion, or action, or both. Diabetes mellitus, commonly referred to as diabetes was first identified as a disease associated with "sweet urine," and excessive muscle loss in the ancient world. Elevated levels of blood glucose (hyperglycemia) lead to spillage of glucose into the urine, hence the term sweet urine. Normally, blood glucose levels are tightly controlled by insulin, a hormone produced by the pancreas. Insulin lowers the blood glucose level. When the blood glucose elevates (for example, after eating food), insulin is released from the pancreas to normalize the glucose level. In patients with diabetes, the absence or insufficient production of insulin causes hyperglycemia. Diabetes is a chronic medical condition, meaning that although it can be controlled, it lasts a lifetime. Over time, diabetes can lead blindness, kidney failure, and nerve damage. These types of damage are the result of damage to small vessels, referred to as micro vascular disease. Diabetes is also an important factor in accelerating the hardening and narrowing of the arteries (atherosclerosis), leading to strokes, coronary heart disease, and other large blood vessel diseases. This is referred to as macro vascular disease. There are three main types of diabetes:

- Type 1diabetes: results from the body's failure to produce insulin, and presently requires the person to inject insulin.
- Type 2diabetes: results from insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency.
- Gestational diabetes: is when pregnant women, who have never had diabetes before, have a high blood glucose level during pregnancy. It may precede development of type 2DM.

Fig.1. Foot Ulcer

2. Test Performed

2.1 Normal Blood Pressure Test

This is the first test in the diagnosis of diabetic foot ulcer. Sphygmomanometer is the instrument used in the blood pressure measurement. It is composed of an inflatable cuff to restrict blood flow, and a mercury or mechanical manometer to measure the pressure. It is always used in conjunction with a means to determine at what pressure blood flow is just starting, and at what pressure it is unimpeded. Manual sphygmomanometers are used in conjunction with a stethoscope. The systolic pressure and diastolic pressure can be measured using this device. Here we are taking only the systolic pressure. The systolic pressure of both right and left hand is measured and then the pressure in the foot ankle also measured. The variation in the pressure is a prior indicator of abnormalities in foot.

Fig.2. Sphygmomanometer

1.1. Monofilament Test

In this simple yet sensitive evaluation, the monofilament, which is a piece of plastic fiber resembling fishing line, is touched against various parts of the sole of your foot, and your ability to feel it at varying pressure is assessed. It is sometimes called the 10 gram monofilament test because the fiber is calibrated to bend to 10 grams of pressure. Your doctor may also use a tuning fork on the bottoms of your feet to see if you can sense the vibration. Nerve conduction studies or velocity tests, which use electrodes to stimulate nerves and then measure the resulting impulses, are a less frequently used, more sophisticated method of diagnosing some neuropathies. Electromyography (EMG), which uses thin needles inserted into the muscles to measure electrical impulses, may also be prescribed. These latter two tests can be painful, and may not be ordered unless there is some question about the diagnosis. So monofilament test is an effective indicator of diabetic foot ulcer.

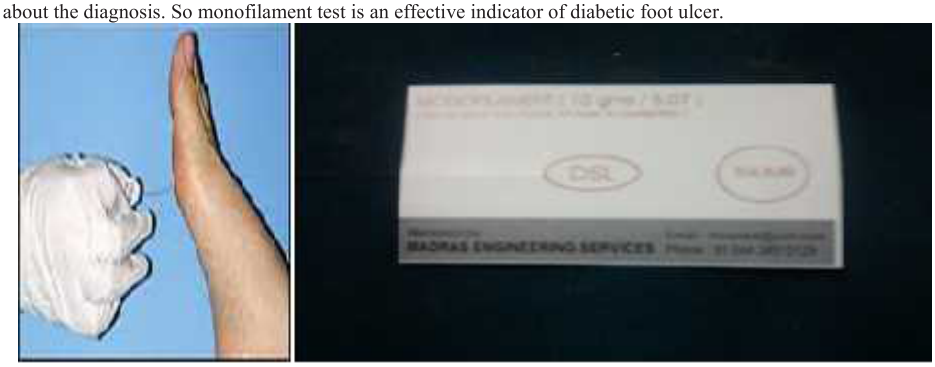

Fig.3. Monofilament Test

1.2. Sensitometer Vibration Pressure Threshold

Vibration Pressure Threshold technique is used to measure the sense of vibration in foot. Here in this technique a vibration is given to the above mentioned 6 areas of foot. The threshold value is the vibration in which the patient can feel. This is an indication of sensational loss in foot.

Fig.4. Sensitometer Vibration Pressure Threshold

1.3. Doppler Test

Doppler test is performed to check whether there is a blood blow in foot region. In this technique a gel is made to spread on the foot area. Then the device is made to move on that area and the blow flow is recognized by a sound and the region with no blood flow will nsssot produce that sound.

Fig.5. Doppler Test

The above tests are done normally to diabetics to check whether they had prone to diabetic foot ulcer. In our project we are introducing a new technique for the early detection of diabetic foot ulcer using pressure sensors.

3. Materials and Methods

Fig.6. System block diagram

It converts the pressure applied into voltage signals. Six points in the foot are taken for the sensor fixation. The voltage coming from the sensor will be in the millivolt range. So it has to be amplified. The amplification circuit is used for this purposely 324 op amp is used for the amplification purpose. The amplified signals are given to the Data Acquisition Device. The graphical representation of the voltage coming out from the six different areas is the output.

The graph analysis is done for the normal and diabetic patients. The age, sex and weight of the subject are important since the variation in analysis is mainly depending in those parameters. High pressure points when compared to normal gives the patient an alarm of getting diabetic foot ulcer in particular area of foot.

3.1. Pressure Mat

Pressure mat is a normal plastic mat where insole is placed on it. Plastic is used as a pressure mat material for the insulation purpose. It is cheap .Insole is a rubber material which has the shape of normal foot. It can be of different shapes depending on sex of the subject .Sensors has to be fixed on these insoles.

3.2. Force Sensitive Resistor

Force Sensitive Resistors (FSR) is a polymer thick film (PTF) device which exhibits a decrease in resistance with an increase in the force applied to the active surface. Its force sensitivity is optimized for use in human touch control of electronic devices. FSRs are not a load cell or strain gauge, though they have similar properties. FSRs are not suitable for precision measurements.

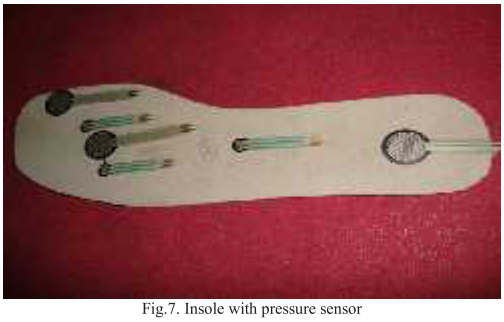

Fig.7. Insole with pressure sensor

3.3. Data Acquisition Device

Data acquisition is the process of sampling signals that measures real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. Data acquisition systems (abbreviated with the acronym DAS or DAQ) typically convert analog waveforms into digital values for processing.

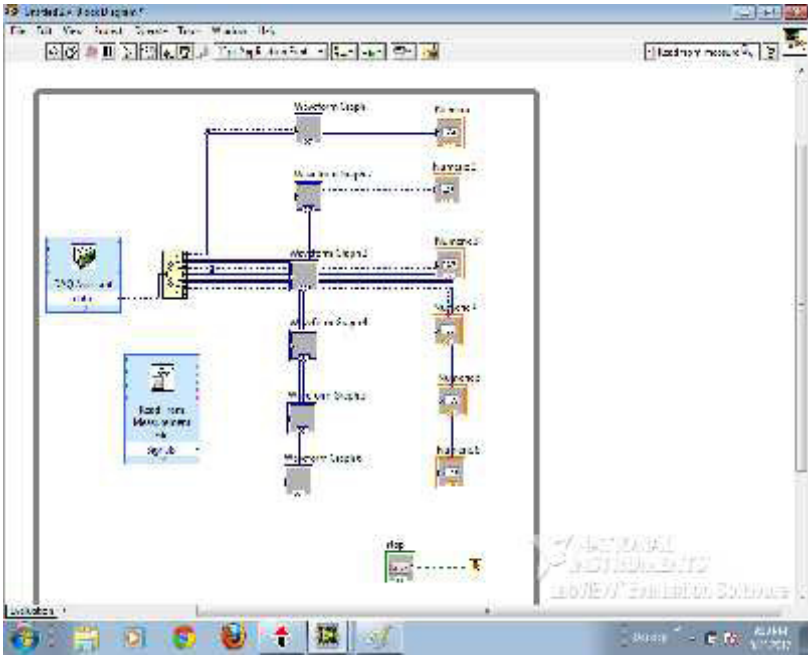

Fig.8. Block Diagram of our result

3.4. LabVIEW

LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a system design platform and development environment for a visual programming language from Instruments. The graphical language is named "G" (not to be confused with G-code).Originally released for the Apple Macintosh in 1986,LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various versions of UNIX, LINUX and MAC OS X. The latest version of Lab VIEW is version Lab VIEW 2011, released in August 2011.

4. Report Analysis

The output got from various subjects are shown below

S.No	Name	Weight	Years of diabetes	Meta Tarsal-i	Meta Tarsal-v	Meta Tarsal-iii	Instep	Great toe	Heal
1	Patient-1(left leg)	58	5	0.08187	3.4482	3.4919	0.990	4.357	5.002
2	Patient-1(right leg)	56	Nil	0.7520	0.4774	0.0518	3.259	0.887	5.169
3	Patient-2	59	3	0.1687	3.40237	3.89228	0.0313	4.6656	4.667
4	Patient-3	61	Nil	0.798	0.5539	1.51817	2.2117	1.6742	3.23
5	Patient-4	46	6	4.327	3.777	4.4073	0.1741	2.9008	4.999
6	Patient-5	42	Nil	3.675	3.5349	4.295	2.5253	4.1708	5.070
7	Patient-6	70	4	0.02813	1.72188	0.36044	0.0441	3.2578	4.602
8	Patient-7	75	9	1.2268	3.93024	4.22634	4.6546	4.7931	4.948
9	Patient-8	55	Nil	0.0665	3.47887	3.5913	0.0339	4.4437	4.884

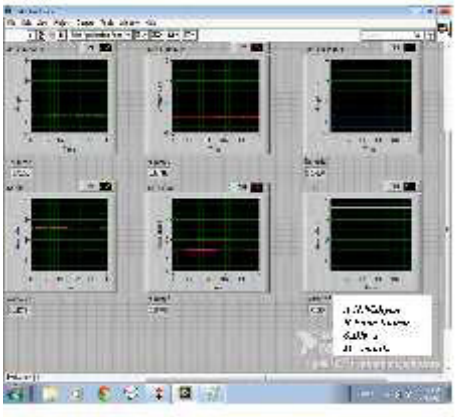

Fig.9. Result obtained in the front panel

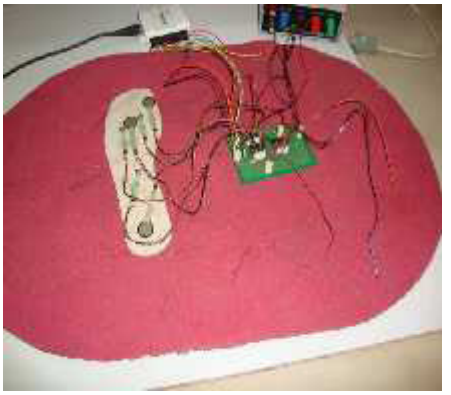

Fig.10.Pressure mat connected to Data Acquisition Device

5. Advantages of this Project

The physician can easily diagnosis the areas of the foot where the possibility of getting foot ulcer is maximum. The output of our project is graphical representation of different pressure points. So the inference is very easy. By merely looking into the graph the physicians can easily diagnoses the foot ulcer prone areas. Frequent testing can be done and by comparing the graph obtained during different tests can be used for the diagnosis purpose. Our project is also cost effective when compared to highly sophisticated equipment's in diabetic research centers since the diabetic treatment has now become costlier. The present equipment for the diabetic treatment is now importing from foreign countries by spending lots of money. This can be avoided by using this diagnosis technique. The total time taken is really less and it is an added advantage for the diabetics who were before waiting for hours for the results.

6. Conclusion

The main aim of our project as said earlier is to measure the pressure variations in plantar region of foot. Mainly six points are taken for the pressure measurement. There will be an increase in the pressure if there is a possibility of getting foot ulcer in a particular area of foot. So any variation in the normal pressure is a good indication of early detection of diabetic foot ulcer. The comparative study of graphs of the normal and the diabetics is a reasonable way of diagnosis of diabetic foot ulcer. Our project is helpful to the present society where the number of diabetic's patient is increasing day by day and also the instance of cases of amputation, also helping in reducing the effect of diabetic's advent on the human body by regular examinations of the pressure value of the patient.

7. References

[1] Harcharan Singh Ranu .Gait Analysis of Diabetic Foot 1995 IEEE
[2] JacobThomas.V, Patil K.M Diabetic feet at risk of plantar ulcers:A New Method of Analysis Of Walking Foot Pressure Images with Changes In Foot Sole Properties 2003, IEEE
[3] Zequera.M, Stephen.S, Paul's Effectiveness of moulded insoles in reducing plantar pressure in diabetic patients. Proceedings of the 29th Annual International Conference of IEEE EMBS held in France, August 23-26,2007.4671-4674
[4] Elisabeth S. Papazoglou, Michael S. Wengarten. Assessment of Diabetic Foot Ulcers With Diffuse Near Infrared Methodology
[5] Ederson A.G. Dorileo,MarcoA.C.Frade Segmentation and analysis of the tissue composition of dermatological ulcers
[6] Keleshis C, Ionita C, Rudin S, C; Ionita, C; Rudin, S (June 2006). "Labview [sic] graphical user interface for micro angio-fluoroscopic high resolution detector". *Medical Physics* **33** (6): 2007.doi:10.1118/1.2240285.
[7] Fedak W, Bord D, Smith C, Gawrych D, Lindeman K, W.; Bord, D.; Smith, C.; Gawrych, D.; Lindeman, K. (May 2003). "Automation of the Franck-Hertz experiment and the Tel-X-Ometer x-ray machine using LABVIEW". *American Journal of Physics* (AAPT) **71** (5): 501–506. doi:10.1119/1.1527949.
[8] Levin and O'neal's The diabetic foot is bn: 978-0-323-04145- 4Copyright © 2008 by Mosby, Inc., an affiliate of Elsevier
[9] Managing the diabetic foot 2nd edition Michael e edmands, alethea vm foster (hons) Copyright 2005 by Blackwell Publishing Ltd Blackwell Publishing, Inc., 350 Main Street, Malden, Massachusetts 2148-5020, USA.
[10]Podiatric assessment and management of the diabetic foot-Churchill Livingstone Elsevier © 2006, Elsevier limited. All rights reserved. First published 2006.
[11]Ramsey, S.D.,K. Newton, D. Blough, D.K. McCulloch, N.Sandhu, G.E.Reber, and E.H.Wagner, Incidence, outcomes, and cost of foot Ulcer in patients with diabetes. Diabetes Care, 1999.22(3):p.382-7
[12]Singh, N., D.G. Armstrong, and B.A. Lipsky, Preventing Foot Ulcers in Patients With Diabetes.2005,Am Med Assoc.p.217-228.